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Environmental Health Center
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In the last ten years there has been a steady movement of people to suburban areas. With this increase in fringe area population, residential sewage disposal systems have come to occupy an important place in American sewage disposal practice. With the availability of electricity and the demand for modern conveniences in our rural areas, the number of individual sewage disposal systems will continue to increase. For example, in recent construction, forty per cent of the homes built with Federal mortgage insurance assistance are dependent upon individual systems for sewage disposal.

The Environmental Health Center, a division of the Public Health Service, has been engaged in a series of studies concerned with individual household sewage disposal systems since late 1946. The underlying purpose of the project is to develop a sound scientific basis for the design of septic tank-soil absorption systems. However, in addition to the investigations concerned with basic design, we have conducted a number of special studies to determine the consequences of various super-imposed loadings. One such study was concerned with the disposal of ground garbage; and it is that study which I will discuss today.

Disposal of ground garbage through the sewage treatment plant is not new to municipal practice. As early as 1923 Fox and Davis(7) investigated

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and described a method for the disposal of garbage at Lebanon, Pennsylvania. Garbage was hauled to a central point, ground and disposed of with the city's sewage in an Imhoff tank. Since that time, numerous investigations have been made, and considerable information concerning the disposal of ground garbage with sewage is available in the literature. We have made use of that information to estimate the quantity and character of garbage produced and its effect on the various treatment processes.

It appears that the per capita quantity of ground garbage produced varies with the locality and the time of the year. In 1941 a survey conducted in various geographical areas by the U. S. Department of Agriculture(1) indicated that production ranged from 0.66 to 1.05 pounds per capita per day. According to the same survey, daily per capita garbage in the ten largest American cities ranged from 0.54 to 0.90 pounds. These figures are somewhat larger than those obtained from other sources. Hering and Greeley(2), indicate a median production of 0.45 pounds per capita per day for 33 selected American cities; American Civil Engineers Handbook(3), 0.52 pounds per capita per day for 20 American cities; the American Public Works Association(4), for 48 cities, a median of 0.64 pounds per capita per day with a range of 0.19 to 1.51 pounds per capita per day. Many writers assume the daily per capita garbage production at 0.5 pounds although it appears from the sources of information above mentioned that a figure of 0.65 pounds might more nearly represent average production.

The maximum rates appear to be in the late summer months when fresh vegetable consumption is at a peak. According to the American Public Works Association(4) the peak month is August with a monthly rate of about 151 per cent of the average; and the low month is February, with a production of about 70 per cent of the average. Figures of Hering and Greeley indicate that the

peak occurs in September with about 133 per cent of the average, and the low in February with production at about 76 per cent of the average.

Moisture content of garbage ranges between 70 and 90 per cent. Assuming an average garbage production of .65 pounds at 80 per cent moisture, the dry weight of garbage solids per person can be taken at .13 pound per day. The peak production with minimum moisture content would amount to approximately .30 pounds per capita per day.

A rough estimate of the increase in load can be made by comparing garbage production figures with the dry weight of solids in a normal sewage. A progress report[13] concerned with sludge digestion presented to the American Society of Civil Engineers stated that the total suspended solids in sewage of typical American cities averaged .21 pounds per capita per day. Several standard text books give .25 pounds per capita per day for suspended solids in an average sewage. Thus it appears that the quantity of dry garbage solids per person is less, but in the same range as the contribution of dry sewage suspended solids. However, a true comparison can not be made unless the quality as well as the quantity of garbage solids is considered.

The composition of garbage solids, so far as they concern sewage treatment, may be most easily understood by comparing them with sewage solids. Rudolfs[5] has made the following comparison with domestic sewage solids:

Table 1 - Comparison of Garbage and Sewage Solids

	Garbage - Per Cent	Sewage Solids Per Cent
Volatile Matter	80-90	70-80
Ash	10-20	20-30
Grease	13-33	15-35
Nitrogen	0.4-1.5	4-6

It is seen from Table 1 that the garbage is higher in volatile matter than the sewage solids and that the nitrogen content of the garbage is considerably lower than that of sewage solids. Thus based on volatile solids as well as quantity, it is reasonable to assume that the addition of ground garbage will roughly double the organic load on the septic tank system.

As for the digestability of garbage, Cohen[13] states that sewage solids and food wastes are basically the same and they act the same (when subjected to anaerobic digestion). Cohen's statement is substantiated by a number of investigators working independently. Malcom[11] conducted a large scale experiment using 55 gallon drums as digestors to which daily additions of raw sludge and ground garbage were made. He concluded, that when measured by volatile solids reduction or by gas production, garbage could be digested either alone or with any proportion of raw sewage and that no difficulty would arise. Bloodgood[8] charged digestion cans daily with primary sludge, activated sludge and garbage. Digestion took place more rapidly in a garbage-raw sludge mixture than in raw sludge alone. Some difficulty was encountered with rising garbage sludge solids. Carpenter, Rogel and Grabois[10] using a ratio of ground garbage and raw sludge to be expected from domestic sewage, found that digestion would take place, and that on a volatile solids basis the process was the same as that for sewage solids alone. Babbitt[9], after a series of experiments, stated that disposal of garbage was simplified. According to Rudolfs, the continuous addition of garbage is not detrimental, but the required capacity of sludge digestors will increase in direct proportion to the increase in volatile matter added. Volatile solids in garbage require the same digestion time as volatile solids in sewage.

In each of the studies cited above the raw garbage and sludge solids were well seeded with digested sludge. That seeding is important was demonstrated by Keefer and Kratz[6]. They found that garbage digested readily and in a normal manner when seeded with one part of volatile digested sludge solids to one part of volatile garbage solids. However, mixtures containing two parts garbage to one part digested sludge lagged some 30 days behind the control, in methane production.

In their study, Carpenter, Rogel and Grabois[10], conducted sedimentation tests using garbage-sewage mixtures compared with sewage alone as a control. Efficiency was higher with garbage sewage mixtures, but in every case the supernatant liquor of the garbage-sewage mixture contained more total solids than the control. This led them to conclude that a mixture of ground garbage and sewage will settle rapidly, but there will be an increase of total solids in the supernatant liquor.

The increase of total solids is probably explained by the work of other investigators. Palmer and Nusbaum[14] found that on grinding an average of 25 per cent of the dry garbage solids would go into solution or nonsettleable suspension during the grinding process. According to Babbitt, Leland and Whitley, 34 per cent of the garbage volatile solids go into solution or suspension in the process of grinding.

Summarizing the information gathered from the literature, it appears that the application of ground garbage to the septic tank system would:

(1) roughly double the organic load placed on the system;

(2) increase the rate of accumulation for sludge and scum;

(3) not interfere with normal anaerobic digestion provided that ample seed material is available, and that ample capacity is provided to prevent overloading;

(4) result in an increase in dry weight of total solids passing through the septic tank to the tile fields.

It appears that all of these possibilities could be accounted for in the disposal system by the application of proper design factors. However, the data cited were gathered for and have direct application to municipal plants. For that reason we have conducted a number of studies dealing directly with the subject of ground garbage as it applies to individual systems.

In order to understand our approach to the problem, and our interpretation of results, I think it would be well to take a moment to discuss the over-all septic tank system. This system depends upon the soil for the ultimate disposal of the liquid fraction of the waste. The soil encountered in most situations is a sensitive medium for waste disposal; and for all practical purposes, can be permanently damaged by abnormal physical and chemical qualities of the effluent discharged to it.

With these cautions in mind, you can readily see that the prime function of the septic tank is to protect the absorption characteristics of the soil. There are three separate processes taking place in the tank which are vital to its successful performance. These are:

(1) Removal of Solids

The reduction in the rate at which effluent percolated through soil cores was in direct proportion to the quantity of suspended solids contained in the effluent. A good septic tank is designed so that settleable solids are removed by sedimentation while floating solids are trapped by the outlet baffle or other device.

(2) Anaerobic Digestion

Our studies have demonstrated that sewage which has been subjected to anaerobic treatment causes less soil clogging than fresh sewage from which the suspended solids have been removed.

(3) Sludge and Scum Storage

Solids trapped in a properly functioning septic tank will digest and compact to a smaller volume. However, no matter how efficient the process is, a considerable amount of relatively inert residue will remain. Space must be provided in the septic tank to store this residue from one cleaning to the next. Otherwise, sludge and scum scoured from the tank might do irreparable damage to the soil field.

These three functions are not compatible, and they are inter-related so that a factor causing a change in one may produce secondary results in the other two. For example, if digestion proceeds too rapidly gasification will interfere with sedimentation and cause sludge solid to refloat, resulting in the loss of stored sludge. A decrease in the rate of digestion results in a good removal of suspended solids with a rapid accumulation of sludge and scum, but as the tank fills with solids the efficiency of suspended solids removal declines.

The nature of soil as a medium for the disposal of liquid, the relationship of the septic tank to the soil-field, and the inter-relationship of processes occurring in the tank are all factors which must be considered when we evaluate the effects of adding ground garbage to the septic tank. By conducting full scale studies of septic tanks in the

laboratory, by comparing the rate of soil clogging caused by a normal effluent with that from a tank receiving ground garbage, and by observing both garbage and normal tanks in actual field use, we have endeavored to obtain results which would present the over-all picture with its many ramifications.

Tank Study

To study the effects of ground garbage on the behavior of septic tanks, two 500-gallon, single-compartment tanks were installed in the laboratory. One of these tanks received raw sewage only and was used as a control. In addition to the raw sewage, the test tank received daily additions of ground garbage from a total of five persons. The garbage was ground in the laboratory and introduced into the tank along with one of the raw sewage feeds.

Daily, each tank received 250 gallons of domestic raw sewage in eight increments. These feeds were made on a schedule which started at 7:00 A.M. and ended with the last feed at 10:30 P.M., seven days each week. The quantity of raw sewage added at each feed varied from 25 to 32.5 gallons to conform to an average daily water consumption pattern. Full details of the feeding and sampling procedures are given in the report, "Studies on Household Sewage Disposal Systems, Part I."(16)

In order to observe the performance of the tanks under the influence of various levels of sludge accumulations, well-digested sludge was added to both tanks at intervals throughout the experiment. The tanks were started with 50 gallons of seed-sludge on August 20, 1947. Another 200 gallons were added during the first week in October, 300 gallons during November, and a final 63 gallons on April 30, 1948.

The experiment was conducted over a ten-month period. During the first seven months the "garbage" tank effluent contained slightly less suspended solids than the control tank. Considering that both of the tanks received the same quantity of sewage solids, the tank receiving ground garbage was performing at a higher rate of suspended solids removal. However, during the last phase of the experiment the quality of the "garbage" tank effluent deteriorated seriously. Where before the effluent suspended solids averaged approximately 118 ppm, during the last three months they rose to an average of 245 ppm. During the same period suspended solids in the "control" effluent rose from 120 ppm to an average of approximatley 165 ppm.

The drop in efficiency has a logical explanation. With the advent of warm weather the rate of digestion increased in both tanks. Partially digested sludge particles and gas bubbles rising through the upper liquid in the tank interfered with normal sedimentation. Digestion of the additional quantity of volatile garbage solids trapped in the test tank would of course magnify the agitation, thus the poor effluent evidenced during the last phase of the experiment.

Digestion proceeded in an alkaline manner in the "garbage" tank throughout the experiment. Effluent pH's ranged between 7.3 and 7.5, and were essentially the same as those for the tank receiving sewage only. Due to the accelerated sludge additions, the test tank was well seeded with digested sewage solids. In actual practice the ratio of digested sewage solids to garbage solids would be much less than that used in our study. Consequently, the value of adequate initial seed material can not be overstressed.

Included as an appendix to this discussion is a tabulation of effluent solids data which were gathered during the experiment. These data permit

several observations. Concerning total solids, the weighted average in the "garbage" tank effluent was 799 ppm compared with 747 ppm in that from the test tank. This difference in total solids was reflected by an average increase of 19 ppm in suspended solids and 33 ppm in dissolved solids. The proportion of volatile matter in the total solids was approximately the same for both tanks, but there seemed to be a tendency toward a larger proportion of volatile matter in the "garbage" tank suspended solids.

A higher ratio of volatile matter in the suspended solids could be evidence of a greater proportion of raw or partly digested solids in the effluent of the "garbage" tank. In this case, the presence of an abnormal amount of suspended volatile solids in the effluent does not indicate interference with anaerobic digestion in the tank. Rather the phenomenon observed is probably one of classification of solids. In the grinding process small particles of volatile garbage solids with an apparent specific gravity approaching unity could be formed. These particles which would neither rise nor settle out by gravity could account for the higher ratio of suspended volatile solids. This is in accordance with two other investigations mentioned earlier to the effect that on grinding 25 per cent of the dry weight of total solids and 34 per cent of the volatile garbage solids become non-settleable.

Effect of Ground Garbage on Soil Clogging

Preliminary information concerning the relative soil clogging caused by effluent from a tank receiving ground garbage was obtained in the laboratory. A number of steel cylinders four inches in diameter were packed with a one-inch bottom layer of pea gravel, eight inches of selected soil, and topped with another one-inch layer of pea gravel. All cores were then dosed with tap water until they were saturated, and an equilibrium percolation rate had been established. Cores whose equilibrium rates were nearly equal were paired as "test" and "control."

The planned effluent treatment was then started. Effluent was applied at a rate sufficient to maintain a free head on the cores at all times. The quantity of effluent and the dry weight of effluent solids applied each day were recorded; so that the decrease in percolation rate could be compared on the basis of time and weight of dry solids added. The difference in percolation rates at any time, or after any given weight of dry solids had been added, was used as evidence of differential soil clogging. A more detailed description of the experimental procedure is given in the "Report on Household Sewage Disposal Systems, Part II."(17)

Cores representing five different soils were treated with "garbage" effluent and compared with identical cores dosed with a normal effluent. The results obtained are tabulated in the appendix of this paper.

After effluent had been applied for a period of two to three months differences in rates between paired cores were examined. In eight of the nine cases, "garbage" effluent had caused a greater degree of soil clogging than the "normal" effluent. This was true when the comparison was made either on an equal time of dosing, or at a point where equal amounts of suspended solids had been added. Average final rate for the "control" cores was 4.4 cc/hr. compared with a final average of 3.7 cc/hr. for the garbage cores, when the comparison was made on a time basis. After equal amounts of suspended solids had been added the final average rates were 5.8 cc/hr. for the "control" cores and 4.4 cc/hr. for the "garbage" cores.

A calculation can be made to show the additional area required so that laboratory soil cores dosed with "garbage" effluent would pass the same quantity in the same time as cores dosed with "normal" effluent. Our

data show that for an equal weight of dry solids added, cores receiving garbage effluent would need an additional 7 to 128 per cent, or on the average an additional 33 per cent of the area required by cores receiving normal effluent.

This, of course, is merely academic. Core studies demonstrate in a qualitative manner the influence that various factors can have on soil clogging; however, the information obtained cannot be applied quantitatively to absorption fields. The increased area required for absorption fields disposing of effluent from a tank receiving ground garbage can be determined accurately only by observing such systems in actual operation.

Field Studies

During the spring and summer of 1951, we took advantage of an opportunity to examine a number of tanks which had been receiving ground garbage. An engineer-laborer team worked in Duval County, Florida, from April until July. In that period thirty-nine systems were opened and examined. Of the thirty-nine systems, sixteen were receiving ground garbage.

For the purpose of our study, Duval County offered several distinct advantages. These included: the active support and cooperation of the county and State health departments; systems of the same age with and without garbage loadings; and systems located under similar climatic and soil conditions.

In making an examination, the first step was to determine the history of the system. This included such information as the time in service, the number of persons residing in the home, the number and types of plumbing units discharged to the tank, and other information related to the use of the system.

Investigations were then carried on in both the tank and the disposal field. The tank was opened and the accumulation of sludge and scum were measured. Sludge and supernatant pH determinations were made, and ground and tank temperatures were recorded. Sections of the tile trench were opened and inspected for accumulation of sludge or other particulate matter. Core samples of soil were taken both from sections of the trench receiving effluent and from nearby soil unaffected by effluent. Percolation tests were made on the soil cores in the field before they were shipped to the laboratory in Cincinnati. At the laboratory the grease content and percentage of organic matter in the soil were determined.

Analyses of the data obtained in Florida are still being made. However, from the work completed thus far, certain facts are obvious. The accumulation of sludge and scum in the tanks receiving ground garbage was compared with sewage only tanks in the same area and also with tanks inspected during the first year of these studies. These comparisons are presented in the following table:

Comparison of Sludge and Scum Accumulations of Garbage and Non-Garbage Septic Tanks

Type	Number of Systems Examined	Average Tank Capacity Gallons	Average Time in Service Years	Average Rate of Accumulation Ft^3/person/year		
				Sc+Sl	Sl	Sc
Garbage	16	751	3.22	3.19	1.72	1.49
Non-Garbage*	21*	617	3.66	1.89	1.36	0.53
Previous Study	120	525	3.66	1.70	1.31	0.39

*Data from two atypical non-garbage tanks discarded.

Close agreement was obtained between the accumulation in non-garbage tanks and in tanks examined in previous studies. The slightly larger accumulation in the Florida tanks is probably the result of increased capacity. Although, statistically speaking, our data do not illustrate that a true difference in accumulation does exist.

The rate of accumulation for the total of sludge and scum in the "garbage" tanks averaged 69 per cent more than "non-garbage" tanks in Florida, and 88 per cent more than tanks examined in earlier studies. The sludge accumulation increased slightly in the "garbage" tanks, about 20 per cent; but the major increase came in the scum accumulation, roughly 200 per cent.

Temperature of the supernatant liquor in all of the tanks inspected averaged 27.6°C, three degrees higher than the ground temperature, which averaged 24.6°C. These temperatures are undoubtedly higher than those in other sections of the country, and may be implicated in the excessive scum formation and acid condition found in most of the tanks. The median observed pH was 6.50 in the "garbage" tanks and 6.84 in the "non-garbage" tanks. It is interesting to observe that only eight tanks had a pH greater than 7.0 and six of these tanks contained no appreciable amount of scum. In all, eight tanks were found with no scum. One of these had a pH of 6.8, one of 6.9 and six had a pH of 7.0 or greater.

The picture obtained from the investigation of disposal fields in Florida is not as clear cut as that obtained from the tanks. Sandy soils with exceptionally high percolation rates were encountered in this area. The nature of the soil tended to minimize any differences which existed; however, some trends have been detected. On the average, percolation rates were

lower in cores taken from "garbage" fields than from the others. For non-garbage fields the average rate was 714 c.c. per hour compared with 688 c.c. per hour for garbage fields. However, the data are extremely variable, and no attempt has been made to demonstrate the significance of the difference in the averages.

There was a slight increase in the organic matter found in cores taken from the "garbage" systems over those taken from the sewage-only systems. For "garbage" systems the organic content ran 0.48 per cent compared with 0.44 in the others, an increase of approximately 10 per cent. Here again, wide variation is encountered between the individual samples, casting doubt on the significance of the difference.

In the future we hope to obtain data on comparable garbage and non-garbage systems operating in a structured soil. Structured soils are more typical of those used for disposal fields throughout the country and are susceptible to chemical and biological as well as physical type clogging.

Summary and Conclusions

Our studies concerned with the disposal of ground garbage in individual systems may be summarized as follows:

A five-hundred gallon septic tank receiving ground garbage and raw sewage was compared in the laboratory with a control tank receiving raw sewage only. The laboratory tank study demonstrated that:

(1) Good removal of garbage solids was obtained in a septic tank during cold weather when the rate of digestion was slow. With the advent of warm weather digestion of the additional garbage solids in the tank increased the agitation and resulted in a period of poor suspended solids removals. (Other studies indicate that the increased agitation could be compensated for by increasing tank capacity.)

(2) Digestion in the "garbage" tank proceeded in a normal alkaline manner with effluent pH's about 7.3 to 7.5. The tank was well seeded with digested sewage solids. (The importance of adequate initial seeding can not be overstressed.)

(3) "Garbage" tank effluent suspended solids contained a higher proportion of volatile solids than effluent of the control tank. The higher ratio was probably the result of classification of solids rather than a lower rate of digestion in the garbage tank.

Soil cores representing five different soil types were dosed with effluent from a septic tank receiving ground garbage. Percolation rates were compared with similar cores being dosed with normal septic tank effluent to establish any tendency towards differential clogging.

(4) "Garbage" effluent caused more clogging than normal effluent. After the same weight of dry suspended solids had been added, the area of laboratory soil cores receiving "garbage" effluent would have to be increased by an average of 33 per cent to pass the same quantity in the same time as cores receiving normal effluent.

Septic tanks and absorption fields of thirty-nine systems located in Duval County, Florida, were opened and inspected. Sixteen of the systems received ground garbage. These examinations revealed that:

(5) After a period in service of approximately three and one-half years tanks receiving ground garbage had accumulated sludge and scum at an average rate approximately 1.7 times as great as tanks receiving sewage only. For the same period between cleanings additional tank capacity for sludge and scum storage is required.

(6) There was a greater increase in scum than in sludge, and as general rule "garbage" tanks were more acid than "non-garbage" tanks. A possibility exists that these conditions were the result of inadequate "seed" material coupled with the warm Florida temperatures.

(7) Sandy soil encountered in Florida was an unfavorable medium for comparing absorption fields of "garbage" and "non-garbage" systems. However, two possible trends were developed. On the average, soil cores from "garbage" fields gave lower percolation rates than "non-garbage," and "garbage" cores contained more organic matter than "non-garbage" cores.

In conclusion, if proper allowance is made for the additional load of volatile solids applied to the over-all system, if provision is made for the increased rate of sludge and scum accumulation, and if adequate initial "seed" material is used, there is nothing in our experiments or in the literature reviewed to indicate that ground garbage cannot be disposed of along with the normal household wastes in a septic tank soil absorption system designed for that load. In other words, if ground garbage is to be disposed of in the septic tank-soil absorption system, both the tank and the disposal field should have additional capacity to provide for the additional load placed on the system.

APPENDIX A

GARBAGE STUDY - EFFLUENT SOLIDS DATA

Date	Digested Sludge Added at Start of Period Gallons	Raw Sewage Fed Gallons	Effluent Solids ppm									
			Total		Total Volatile		Suspended		Suspended Volatile		Ratio SV3/SS	
			Control	Garbage	Control	Garbage	Control	Garbage	Control	Garbage	Control	Garbage
8/20 to 9/23/47	50.0	7,490	642	716	218	292	109	103	80	84	.73	.82
10/11 to 11/8/47	200	7,580	716	721	231	217	123	123	75	79	.61	.64
11/24/47 to 2/15/48	300	18,280	772	819	199	217	123	118	93	92	.73	.78
2/23 to 4/28/48	-	6,410	826	767	250	234	173	126	99	86	.57	.68
4/30 to 6/28/48	62.5	19,420	749	853	236	301	160	245	92	151	.58	.62
Weighted Average			747	799	223	256	140	159	89	108	.64	.68

APPENDIX B

SOIL CLOGGING CAUSED BY SEWAGE PLUS GARBAGE EFFLUENT AS COMPARED WITH THAT CAUSED BY NORMAL EFFLUENT

Soil Type	Percolation Rate cc/hr. After Dosing Cores Equal Length of Time		Percolation Rate cc/hr. After Equal Dry Weight of Suspended Solids Added	
	Normal	Garbage	Normal	Garbage
Miami Clay Loam (1)	6.0	5.7	9.0	8.4
Miami Clay Loam (2)	4.4	3.6	8.2	3.6
Genessee Silt Loam (1)	6.9	3.9	9.0	5.4
	3.4	3.0	3.5	3.2
Genessee Silt Loam (2)	3.7	3.0	5.5	3.2
	3.3	2.9	4.1	2.7
	3.2	3.8	3.7	4.1
Genessee Loam	5.0	3.9	5.5	4.8
	3.9	3.4	4.1	4.3
Average	4.4	3.7	5.8	4.4

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